Grosenbaugh

FINANCIAL MATURITY OF BOTTOM-LAND RED OAKS AND SWEETGUM

Sam Guttenberg and John A. Putnam

SOUTHERN FOREST EXPERIMENT STATION
Harold L. Mitchell, Director

OCCASIONAL PAPER 117 (reissued)

March 1951

FINANCIAL MATURITY OF BOTTOMLAND RED OAKS AND SWEETGUM

By

Sam Guttenberg and John A. Putnam[1/]
Southern Forest Experiment Station

This paper offers a method for determining financial maturity of a tree--that is, for deciding when to cut a tree in order to make the most money from growing and harvesting it. The method is illustrated with the sweetgum and bottomland red oaks (Nuttall, willow, water, and cherrybark oaks) found in the Mississippi River Delta and other southern river bottoms subject to periodic overflow.

The idea of financial maturity is this:

Profitable timber management consists in obtaining, and in tapping for harvest, a stand of trees fully-stocked, fast-growing, and of high quality. From time to time, the forest manager visits each acre and marks for removal those trees whose quality or growth rate is below par. Bearing in mind how the typical tree develops--low value at first but rapid increase in value; a gradual slackening in the rate of increase until the stage is finally reached where the tree ceases to pay its way--the manager appraises his trees with the object of putting the ax to those that are reaching this crucial point. This is the point of financial maturity.

The financial-maturity idea can be used, if properly adapted, under any silvicultural system. Here, with bottomland hardwoods as the illustration, the idea is developed with many-aged (individual-tree or group-selection) systems of management mainly in mind. Following is the gist of the method for recognizing financial maturity:

1/ Mr. Putnam is stationed at the Delta Branch of the Southern Forest Experiment Station. This Branch is maintained in cooperation with the Mississippi Agricultural Experiment Station at Stoneville, Mississippi.

1. Determine the rate of return that is desired from the money invested in the tree. This rate will usually depend on what could be obtained by taking the money out of the tree and investing it elsewhere. It is called the alternative rate of return.

2. Determine how tree volume and quality are related to tree diameter. Thus, a 22-inch red oak with a grade 1 butt log and a grade 2 second log has a volume of 294 board feet. When it reaches 24 inches, the volume will be 358 board feet and the grade will probably be unchanged.

3. Determine the value of trees according to volume, grade, and diameter, thus making it possible to predict value. For example, the same 22-inch red oak has a value of about $9.56. At 24 inches, its value will be $13.35.

4. Determine reliable rules for judging the vigor of trees as an index of their prospective diameter-growth rate. The appearance of bark and crown of the 22-inch oak indicates, for the sake of the example, that the tree will grow 2 inches in diameter over the next 10-year cutting cycle.

5. Determine the prospective rate of increase in tree value. An increase from $9.56 to $13.35 in 10 years represents an annual rate of 3.4 percent compound interest. If the alternative rate of return is 4 percent, the oak, considered by itself, is financially mature and should be marked for cutting.

6. Determine whether the influence of other trees will affect the financial maturity decision. If there is a mature tree of lower value crowding the 22-inch oak, removal of this lower-value tree may increase the oak's growth to 3 inches in 10 years and its rate of value increase to 4.9 percent. In this case, the oak is financially immature and should be left to grow at least one more cutting cycle if the alternative rate of return remains 4 percent.

In what follows, details of the financial-maturity method are given in order for each of the six steps outlined. After this, some ready-made, simplified marking guides for bottomland red oaks and sweetgum are discussed. The full text is intended for readers who wish to follow the reasoning behind the method or to use the method as a basis for working up marking rules for their particular forest tracts. The reader who is interested more in the bottomland hardwood example than in the method as such may turn directly to step 4. Those whose main interest is in marking guides will find them on page 25.

Step 1 --Alternative Rate of Return

The alternative rate of return against which a tree's rate of value increase is judged in determining financial maturity is a thing peculiar to each forest owner, whether individual or corporate. Some owners have alternative uses for their capital that will yield at a high rate; for other owners, the best alternative may promise but a low yield. Consequently each owner must work out his own alternative rate of return.

An owner's alternative rate may be determined by his opportunities either for investing funds or for spending them. In the case of investment, the rate may be set "by the prospective rate of return on new forest land, on planting or other cultural measures, or simply on the bonds of some borrower in or out of forestry enterprise. For spending, too, the return available from funds is in general expressible. For example, the cost of borrowing tends to determine the premium on funds for meeting business expenses, and individual time preference is similarly determinative in personal consumption....

"In determining the alternative rate of return, there are three noteworthy considerations: (1) Where the rate is based upon the net return from alternative investments, this return must be estimated after income taxes, since funds derived from reinvestment of liquidated timber capital are subject to one more income taxing than are funds taken directly from the timber capital. (2) Where there is more than one alternative rate of return, the highest rate governs. (3) Where the alternative use of funds involves a different degree of risk than is involved in the growing-stock investment, the alternative rate of return must be adjusted to terms of equal risk." 2/

Whatever the rate that is desired, a decision on the matter is essential to any determination of financial maturity. When the forest manager and the owner are the same person, no problem will arise in putting the alternative rate into practice. Where the forest manager is the owner's agent, he must know the alternative rate of return that is desired before he can carry out the owner's policy successfully.

2/ Duerr, William A., and Bond, W.E. Optimum stocking of a selection forest. Jour. Forestry 50:12-16. January 1952.

Step 2 -- Volume and Quality

How to express tree volume and quality will depend on the products for which the trees are being grown. For bottomland red oaks and sweetgum, it is assumed that the goal of the forest manager will be the production of standard factory lumber. Such lumber makes up about 70 percent of total hardwood consumption and represents, in general, the highest use of bottomland hardwoods. A notable exception is face veneer, and the manager who intends to grow much of this product will need to make special studies of financial maturity. On the other hand, special consideration probably need not be given to such products as package veneer, slack cooperage stock, cross ties, pulpwood, and fuel wood, plenty of which will inevitably be grown as a byproduct of the sawlog objective.

With standard factory lumber in view, this paper expresses tree volume in board feet by the International 1/4-inch kerf rule. 3/ Tree quality is expressed in terms of log grades--for example, a two-log tree with a grade 1 butt and a grade 3 second log is classed as grade 1-3. The log grades used are those recently developed by the Forest Products Laboratory. 4/ Facility in the use of these log grades is essential in making financial-maturity decisions. Special training and experience in the field are required. Familiarity with the log defects upon which the grades are based is especially important. 5/

Step 3 -- Value

Tree value will here be expressed in terms of conversion surplus. Conversion surplus is described more fully elsewhere 6/. In brief, however, it is the difference between the sales value of the end product--in this case, standard factory lumber--and all the direct costs of converting the trees into this lumber--mainly labor and materials

---

3/ Mesavage, C., and Girard, J. W. Tables for estimating board-foot volume of timber. U. S. Dept. Agr., 94 pp. 1946. For sale by the Superintendent of Documents, Wash. 25, D. C.

4/ Hardwood log grades for standard lumber: proposals and results. U. S. Forest Products Laboratory D 1737, illus. 1949.

5/ Lockard, C. R., Putnam, J. A., and Carpenter, R. D. Log defects in southern hardwoods. U. S. Dept. Agr. Agr. Handbook 4, 37 pp., illus. 1950.

6/ Guttenberg, S., and Duerr, William A. A guide to profitable tree utilization. South. Forest Expt. Sta. Occas. Paper 114, 18 pp., illus. 1949.

used in felling the tree and in making, transporting, and sawing the logs. Conversion surplus thus represents that part of a tree's gross product value which can be made available to increase profit or reduce loss. In the financial-maturity problem, the rate of a tree's earning is compared with the rate obtainable from alternative uses of money, with the intention of liquidating and transferring the investment in the tree if its rate of earning is below the alternative rate. The transferable investment in a tree is its conversion surplus.

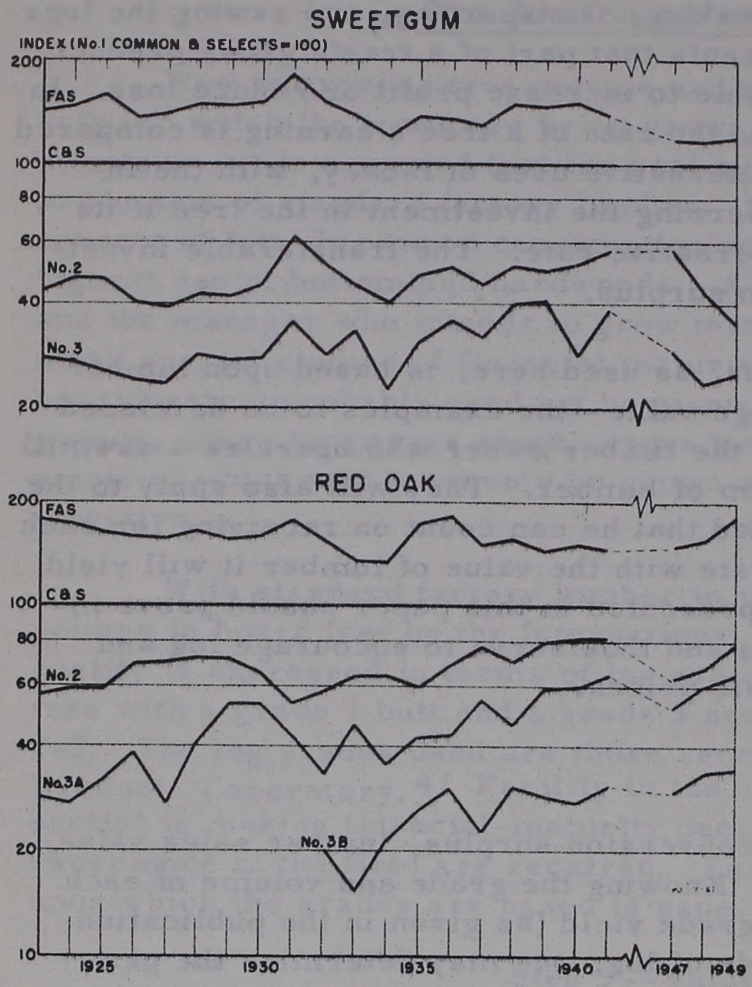
Since conversion surplus, as used here, is based upon lumber value--not log value or stumpage value--the examples to be developed will be applicable primarily to the timber owner who operates a sawmill and sells his product in the form of lumber. They will also apply to the log or stumpage seller, provided that he can count on receiving for each log or tree a price commensurate with the value of lumber it will yield. Indeed, the data on tree value presented in this paper should prove informative to buyers and sellers and thus serve to encourage log and stumpage sales at commensurate prices.

Lumber sales value

The first ingredient of conversion surplus, lumber sales value, can be estimated for any tree. Knowing the grade and volume of each log in the tree and the lumber grade yield (as given in the publication cited in footnote 4) of each grade of log, one may determine the percentage of total tree volume by lumber grade. With current sales prices for lumber, he may then calculate the weighted average price per thousand board feet of lumber represented in the tree, and from this the total value of the lumber in the tree.

The problem is how to allow for changes in the lumber market. An estimate of financial maturity involves looking ahead at least one cutting cycle--perhaps 10 years or more. We can be reasonably sure that the lumber price level will not be the same then as now. It may be higher--or perhaps lower. To help solve this problem, advantage may be taken of the fact that with all the ups and downs of the lumber market, the price of each grade tends to maintain a fairly stable relationship to that of other grades. 7/ Grade prices may then be expressed as percentages (index numbers) that will have some validity over the years, and the value of lumber in a tree may be calculated in index terms instead of dollar terms, following the same procedure as would be used with dollars.

7/ Herrick, A. M. Grade yields and overrun from Indiana hardwood sawlogs. Purdue Univ. Bul. 516, 59 pp., illus. 1946.



Lumber grade index values per MBM

In the chart at the left, value index numbers for each grade of red oak and sweetgum lumber are plotted for the period 1923 to 1949, omitting the abnormal war years. These numbers were derived from annual average lumber grade prices. The grade prices are expressed as relatives in percent of the price of Number 1 Common and Selects. The data were obtained from Southern Hardwood Producers, Inc. of Memphis. They are representative prices, f. o. b. southern bottomland hardwood mills, for air-dried stock 4/4 inch and thicker. Because the lower grades of lumber have commanded relatively high prices in recent years as these grades have come into wider demand--a condition that is expected to continue--index numbers were determined as the average of price relatives for the years 1937 through 1941 and 1947 through 1949, with each year allowed equal weight.

The resulting indexes are as follows:

Lumber grade	Red oak	Sweetgum
Firsts and Seconds	156	134
No. 1 Common and Selects	100	100
No. 2 Common	75	49
No. 3 Common	...	32
No. 3A Common	58	...
No. 3B Common	30	...

What these numbers mean--using sweetgum as an example--is that in any marketing period, whatever price is being received for No. 1 Common and Selects, 134 percent of that price will probably prevail for First and Seconds, 49 percent for No. 2 Common, and 32 percent for No. 3 Common.

Direct costs

The other ingredient of conversion surplus, direct costs of lumber production from stump through mill, is estimated on the basis of whatever cost records are available. Direct costs include only those additional outlays that arise because the tree in question is being made into lumber. They specifically exclude all fixed or overhead costs--those costs that are unaffected by whether the particular tree is logged and milled.

For bottomland red oaks and sweetgum, available logging and milling study experience was used as a basis for estimating direct costs on a typical operation.[8/] Costs were estimated in dollars per thousand board feet for trees of each species group, diameter class, and log height. Dollars were then converted to relatives in percent of the price of No. 1 Common and Selects lumber, just as was done for lumber value. This procedure is defensible on the ground that prices and direct costs (primarily wage rates) tend to fluctuate together. It makes it possible to derive conversion surplus as an index number, and thus avoid, throughout, the problem of variable dollars discussed above. The result of these calculations is given below, under step five.

Step 4 --Vigor

Tree vigor as an index of prospective diameter growth can be judged from external indicators. In bottomland hardwoods, the single most reliable indicator is the bark. Bark features stand out so strongly and are apparently so reliable that some others--site, age, root system--can largely be ignored. The crown, however, furnishes additional evidence that should be considered.

The vigor classes defined below do not apply to cull trees or poor-risk trees. They are meant to be used on trees at least 16 inches d. b. h., approximately the minimum tree size for production of standard hardwood factory lumber in the South. Three vigor classes--high, medium, and low--suffice for all practical purposes and are clearly enough dis-

8/ The principal sources of these estimates are given on p. 18 of the publication cited in footnote 6. However, judgment was used liberally to fill in the gaps in data available for the bottomland hardwoods.

tinguished so that the forester or woodsman can with practice learn to recognize them and thus to estimate prospective growth with minimum use of an increment borer. Tables 1 and 2 summarize distinguishing features of the three vigor classes for bottomland red oaks and sweetgum. The growth rates associated with these classes are as follows:

Vigor class	10-year diameter growth, inches	
	Red oaks	Sweetgum
High	3-1/2 - 4-1/2*	3 - 4
Medium	2-1/2 - 3-1/2	2 - 3
Low	1-1/2 - 2-1/2	1 - 2

*Exclusive of red oaks of super-vigor.

Table 1. --Bark and crown characteristics of red oaks, by vigor class

High vigor	Medium vigor	Low vigor
Bark: Healthy, fully normal in color, glossy to lustrous, fairly thin and smooth, but with shallow, wide fissures exposing fleshy, bright yellow to orange inner bark which contrasts markedly with dark outer bark. The bark is most conclusive indicator.	Bark: Compared with high vigor, fissures less wide, inner bark duller and generally less conspicuous. Overall, bark is somewhat rougher and darker.	Bark: Dark, thick, narrowly fissured. Little or no live tissue exposed in fissures.
Crown: 3/4 or more fully formed and without close competition. Full and thrifty, with profuse long, upward-reaching young branches and twigs, light colored and lustrous. No dying leaders or dead stubs in upper part. Foliage abundant and lustrous. Crown quality and vigor more important than length or volume, except that a high ratio of crown length to stem length is a significant indicator.	Crown: 1/2 or more well formed, with abundant foliage, and without close competition. Some crowns may be entirely free of competition, but twigs will be thicker and fewer and foliage scantier than in high-vigor crowns.	Crown: Small and poorly formed, or open. Thinly foliated.

Table 2. --Bark and crown characteristics of sweetgum, by vigor class

High vigor	Medium vigor	Low vigor
Bark: Light ash-gray, corky, thick, with pronounced rounded ridges. Bottoms of fissures display streak of very light inner bark.	Bark: Gray, thick, somewhat corky (or at least with ridges slightly rounded), and free of scales or plates. Bottoms of fissures narrow, only occasionally displaying thin streak of inner bark.	Bark: Compared with medium vigor, darker, thinner, flatter. No display of inner bark. May be scaly.
Crown: 3/4 or more without close competition. Full and healthy, composed preponderantly of small ascending leaders and twigs. Foliage abundant and lustrous. Other things being equal, high ratio of crown length to stem length indicates high vigor.	Crown: 1/2 or more well formed and without close competition. Some crowns are small because of competition, but have preponderance of small twigs and abundant foliage; others are large, but heavy-limbed and with thin foliage. Foliage always of good color. Little sign of dry-topping.	Crown: Compared with medium vigor, smaller or more preponderantly heavy-limbed and with thinner foliage. Foliage may be pale. Some trees may be stag-headed or dry-topped.

The red oaks (figs. 1 through 4) in the highest vigor class generally have smooth, thin bark with wide, open fissures vividly colored at bottom. As vigor declines, the bark thickens and roughens; fissures narrow, becoming discontinuous and obscure in low-vigor trees. Decadent red oaks, those below the class of low vigor, are usually degenerate or dying, are often stagheaded, and generally have excessive die-back of twigs. The bark (figs. 1D and 4D) looks dull, bleached, and sickly, or else is thick, dark, and very rough. Abundant epicormic branching is common. At the other end of the scale, a super-vigor class of red oaks may be recognized, capable of growing 5 or 6 inches in diameter in 10 years. Such trees exhibit the most favorable bark and crown characteristics to an extreme degree.

By contrast with the red oaks, sweetgum trees of highest vigor are characterized by the thickest bark, with distinct high ridges. In lower vigor classes the bark is flatter and thinner (fig. 5).

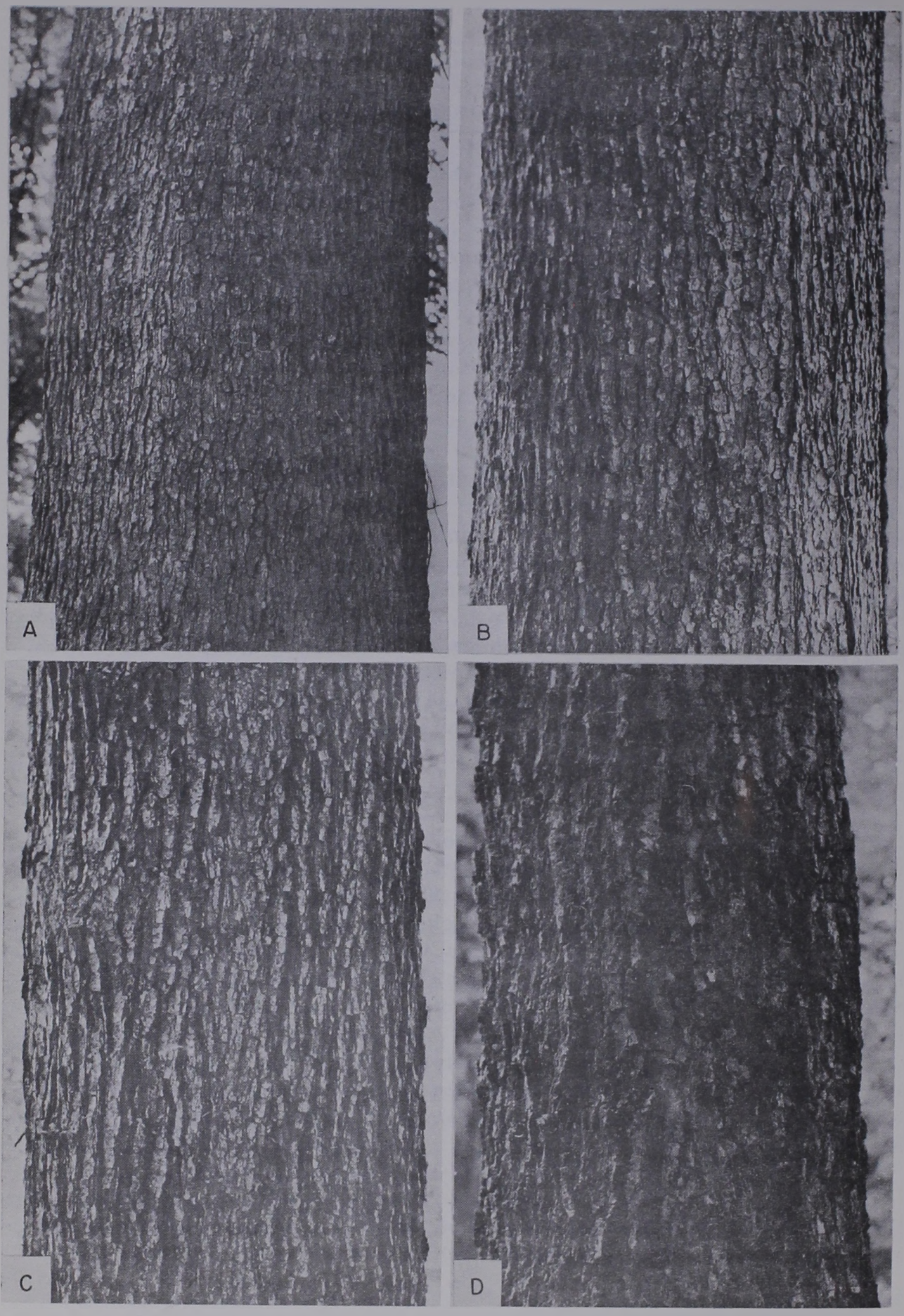


Figure 1.— Cherrybark Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, Decadent.

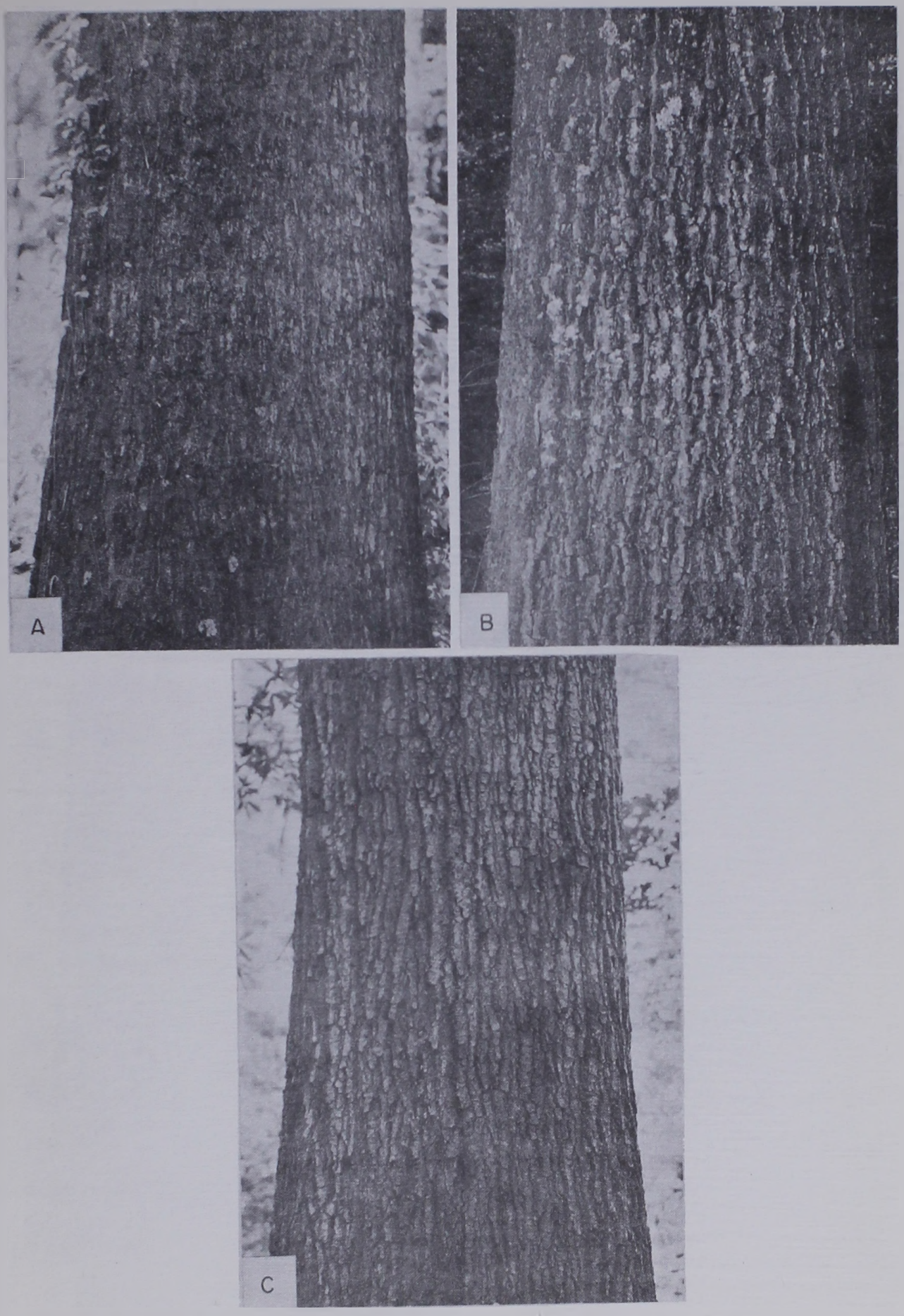


Figure 2.—Willow Oak. *A*,High vigor. *B*,Medium vigor. *C*,Low vigor.

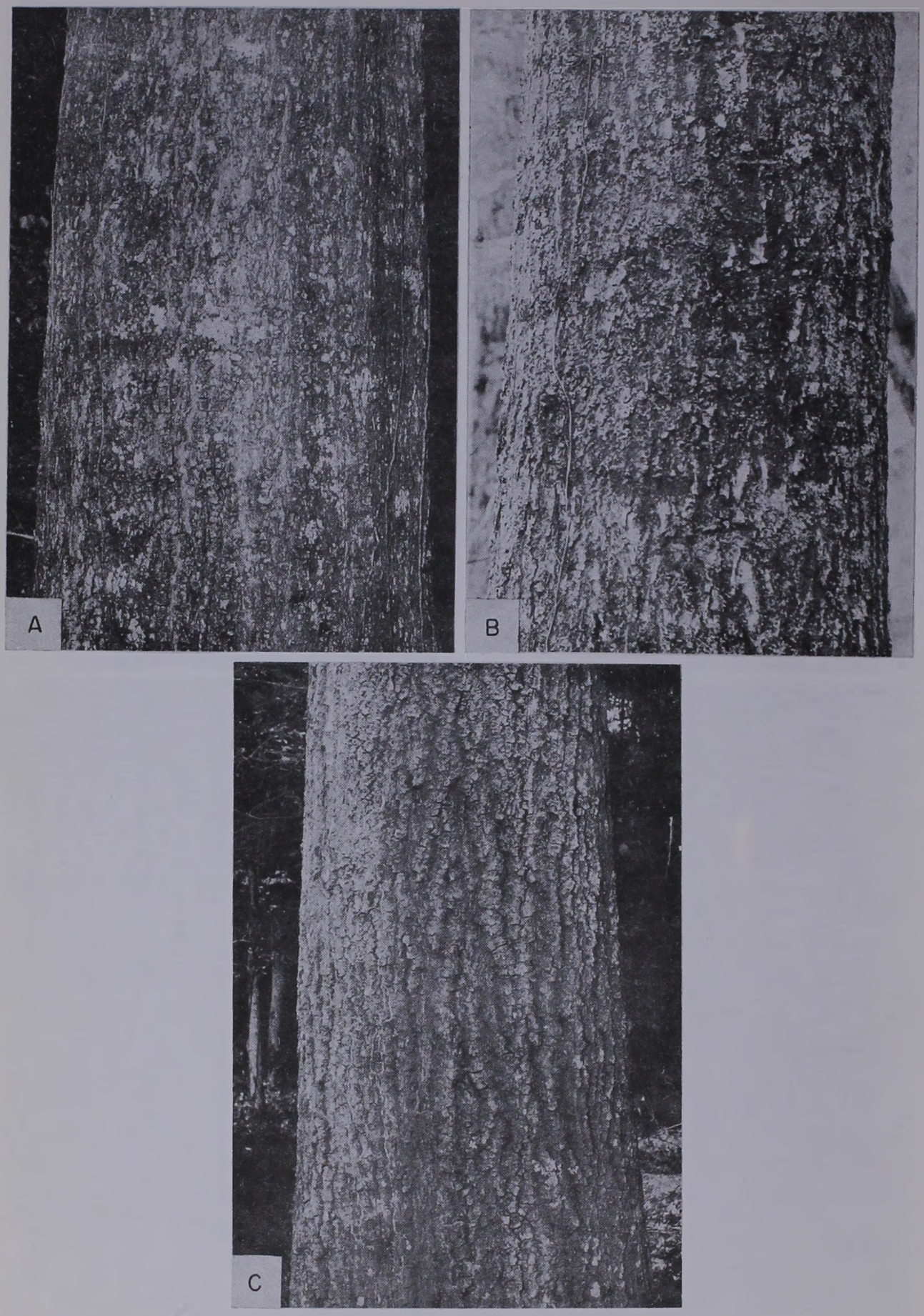


Figure 3.—Water Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor.

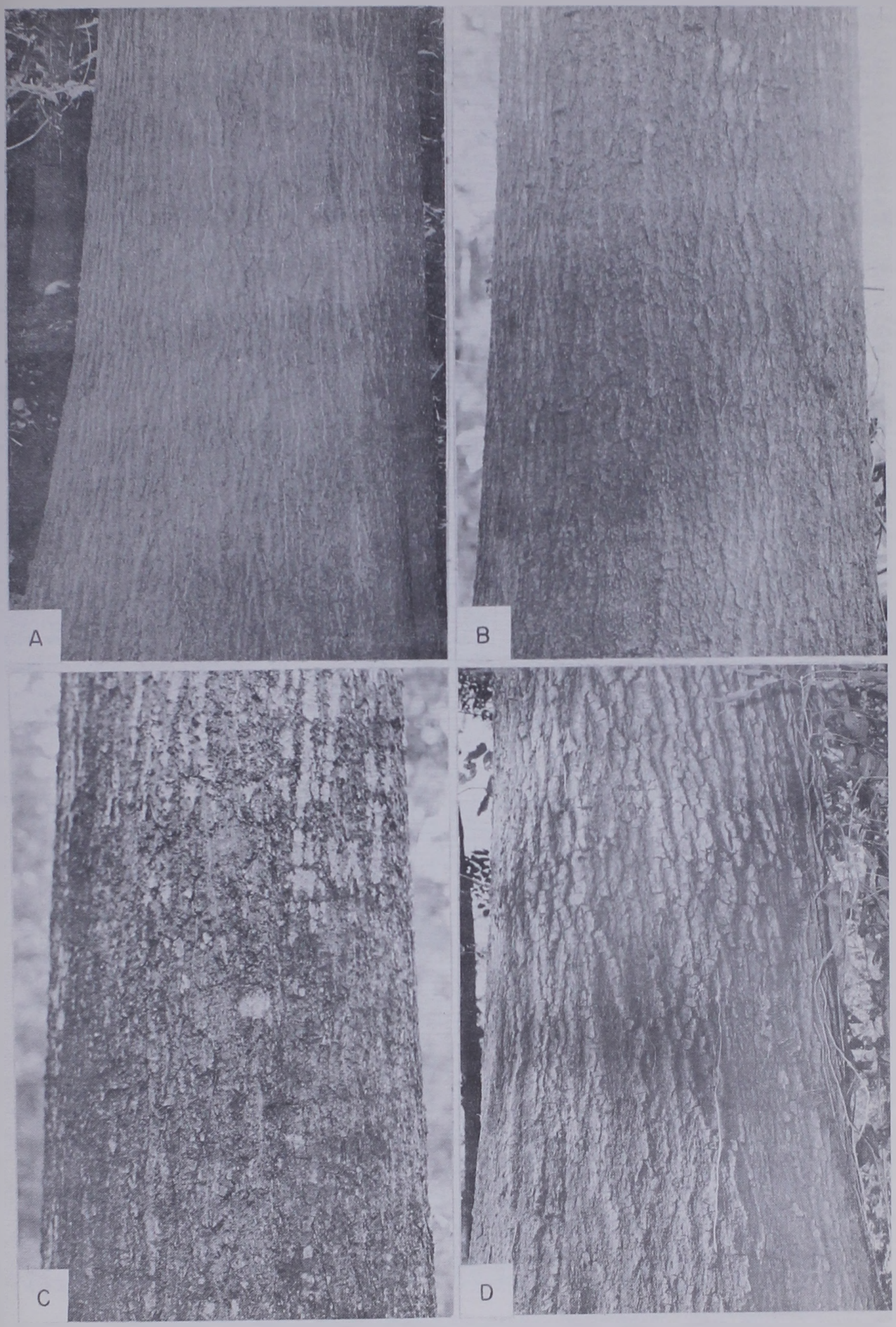


Figure 4.—Nuttall Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, Decadent.

Figure 5.—Sweetgum. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, Decadent.

Step 5 --Rate of Value Increase

With vigor or growth classes defined, and with a method determined for expressing tree value according to tree size and quality, we are ready to determine rate of increase in tree value, the rate that is to be compared with the alternative rate of return to see if a tree is financially mature. The problem will be considered in two stages: first, rate of value increase when a tree changes diameter but not log height or grade; second, rate of increase when height or grade, as well as diameter, changes.

In continuing the illustration for bottomland red oaks and sweetgum, a 10-year cutting cycle is assumed. That is, it will be supposed--and this is realistic for the region--that the manager has the choice of cutting a tree now or waiting at least 10 years. Consequently our interest centers on the rate of tree-value increase in 10 years.

No change in log height or grade

Rates of value increase for bottomland red oaks and sweetgum of each vigor class are presented in tables 3 and 4. Columns 2, 3, and 4 show, in terms of index numbers as explained earlier, the lumber value, the direct costs, and the difference between these two--the conversion surplus--per thousand board feet as a weighted average for the tree. Given the number of board feet per tree as shown in column 5, the present conversion surplus per tree is read from column 6. Columns 7, 9, and 11 show the prospective conversion surplus after 10 years for each vigor class, assuming average d. b. h. growth for the class and no change in log height or grade. The ratio of value after 10 years to value now determines for each vigor class (columns 8, 10, and 12) the compound rate of annual increase.

Take the problem of a forest manager who is deciding whether to mark a two-log 28-inch Nuttall oak, grade 1-2, high vigor--or whether to let it grow for another 10 years. Large limbs above the second log permanently limit the merchantable height, nor is the grade of either log likely soon to improve. The alternative rate of return which the manager follows as his guide is 5 percent. Table 3 indicates that this Nuttall oak will earn less than this rate--only 4. 4 percent--in the coming decade. It is therefore financially mature and should be marked for cutting.

Changes in height and grade

Both log height and grade normally change as a tree grows in diameter. Small limbs die and fall off, and clear wood covers the knots.

Table 3.--Rate of value increase of red oaks by log height, grade, diameter, and vigor class

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Per M board feet: Direct costs (3)	Per M board feet: Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	High vigor: Annual increase (8)	Medium vigor: After 10 yrs. (9)	Medium vigor: Annual increase (10)	Low vigor: After 10 yrs. (11)	Low vigor: Annual increase (12)
	Index	Index	Index	Bd.ft.	Index	Index	Percent	Index	Percent	Index	Percent
				1-LOG-TREES, GRADE 1							
18	85.5	61.8	23.7	112	2.65	6.37	9.1	5.30	7.2	4.36	5.1
20	87.9	57.0	30.9	141	4.36	8.59	7.0	7.40	5.4	6.37	3.9
22	90.2	53.6	36.6	174	6.37	11.26	5.9	9.88	4.5	8.59	3.0
24	92.1	51.0	41.1	209	8.59	14.28	5.2	12.70	4.0	11.26	2.7
26	94.6	49.0	45.6	247	11.26	17.70	4.6	15.94	3.5	14.28	2.4
28	96.8	47.4	49.4	289	14.28	21.35	4.1	19.49	3.2	17.70	2.1
30	99.2	46.2	53.0	334	17.70	25.63	3.8	23.43	2.8	21.35	1.9
32	101.3	45.4	55.9	382	21.35	30.06	3.5	27.89	2.7	25.63	1.8
34	104.0	44.8	59.2	433	25.63	34.21	2.9	32.14	2.3	30.06	1.6
36	106.2	44.6	61.6	488	30.06	38.45	2.5	36.23	1.9	34.21	1.3
				GRADE 2							
16	70.0	68.0	2.0	87	.17	2.27	29.5	1.64	25.4	1.08	20.3
18	71.4	61.8	9.6	112	1.08	3.72	13.2	2.95	10.6	2.27	7.7
20	73.1	57.0	16.1	141	2.27	5.37	9.0	4.53	7.2	3.72	5.1
22	75.0	53.6	21.4	174	3.72	7.31	7.0	6.32	5.4	5.37	3.7
24	76.7	51.0	25.7	209	5.37	9.57	5.9	8.40	4.6	7.31	3.1
26	78.6	49.0	29.6	247	7.31	12.16	5.2	10.84	4.0	9.57	2.7
28	80.5	47.4	33.1	289	9.57	14.97	4.6	13.52	3.5	12.16	2.4
30	82.6	46.2	36.4	334	12.16	17.68	3.8	16.31	3.0	14.97	2.1
32	84.6	45.4	39.2	382	14.97	20.49	3.2	19.06	2.4	17.68	1.7
				GRADE 3							
18	63.8	61.8	2.0	112	.22	2.09	25.2	1.57	21.7	1.10	17.5
20	64.8	57.0	7.8	141	1.10	3.26	11.5	2.62	9.1	2.09	6.6
22	65.6	53.6	12.0	174	2.09	4.57	8.1	3.91	6.5	3.26	4.5
24	66.6	51.0	15.6	209	3.26	6.13	6.5	5.33	5.0	4.57	3.4
26	67.5	49.0	18.5	247	4.57	7.85	5.6	7.00	4.4	6.13	3.0
28	68.6	47.4	21.2	289	6.13	9.52	4.5	8.69	3.6	7.85	2.5
30	69.7	46.2	23.5	334	7.85	11.35	3.8	10.40	2.8	9.52	2.0
				2-LOG-TREES, GRADE 1-2							
18	80.7	61.2	19.5	182	3.55	9.56	10.4	6.87	6.8	6.32	6.0
20	82.7	55.8	26.9	235	6.32	13.35	7.8	11.38	6.1	9.56	4.2
22	84.7	52.2	32.5	294	9.56	17.80	6.4	15.46	4.9	13.35	3.4
24	86.9	49.6	37.3	358	13.35	22.96	5.6	20.23	4.2	17.80	2.9
26	89.0	47.5	41.5	429	17.80	28.89	5.0	25.85	3.8	22.96	2.6
28	91.2	46.0	45.2	508	22.96	35.24	4.4	32.04	3.4	28.89	2.3
30	93.5	44.7	48.8	592	28.89	42.28	3.9	38.60	2.9	35.24	2.0
32	95.5	43.9	51.6	683	35.24	49.95	3.5	46.08	2.7	42.28	1.8
34	97.6	43.4	54.2	780	42.28	57.79	3.2	53.85	2.4	49.95	1.7
36	99.8	43.3	56.5	884	49.95	65.87	2.8	61.80	2.2	57.79	1.5

Table 3.--(Continued)

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Direct costs (3)	Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	High vigor: Annual increase (8)	Medium vigor: After 10 yrs. (9)	Medium vigor: Annual increase (10)	Low vigor: After 10 yrs. (11)	Low vigor: Annual increase (12)
	Index			Bd.ft.	Index		Percent	Index	Percent	Index	Percent
					GRADE 1-3						
18	74.3	61.2	13.1	182	2.38	7.70	12.5	6.15	10.0	4.84	7.3
20	76.4	55.8	20.6	235	4.84	11.03	8.3	9.25	6.7	7.70	4.8
22	78.4	52.2	26.2	294	7.70	14.97	6.9	12.94	5.3	11.03	3.7
24	80.4	49.6	30.8	358	11.03	19.61	5.9	17.15	4.5	14.97	3.1
26	82.4	47.5	34.9	429	14.97	24.75	5.1	22.12	4.0	19.61	2.7
28	84.6	46.0	38.6	508	19.61	31.01	4.7	27.70	3.5	24.75	2.4
30	86.5	44.7	41.8	592	24.75	36.00	3.8	33.42	3.0	31.01	2.3
32	88.7	43.3	45.4	683	31.01	41.90	3.2	38.87	2.3	36.00	1.5
					GRADE 2-3						
18	67.6	61.2	6.4	182	1.16	5.23	16.2	4.09	13.4	3.08	10.3
20	68.9	55.8	13.1	235	3.08	7.73	9.7	6.43	7.6	5.23	5.5
22	70.0	52.2	17.8	294	5.23	10.68	7.4	9.16	6.4	7.73	4.0
24	71.2	49.6	21.6	358	7.73	14.02	6.1	12.28	4.7	10.68	3.3
26	72.4	47.5	24.9	429	10.68	17.94	5.3	15.94	4.1	14.02	2.8
28	73.6	46.0	27.6	508	14.02	22.47	4.8	20.07	3.7	17.94	2.5
30	75.0	44.7	30.3	592	17.94	26.96	4.2	24.60	3.2	22.47	2.3
32	76.2	43.3	32.9	683	22.47	31.86	3.6	29.40	2.7	26.96	1.8
					GRADE 3-3						
18	62.2	61.2	1.0	182	.18	3.12	32.8	2.33	29.2	1.55	23.9
20	62.4	55.8	6.6	235	1.55	4.83	12.0	3.96	9.8	3.12	7.3
22	62.8	52.2	10.6	294	3.12	6.82	8.1	5.78	6.4	4.83	4.4
24	63.1	49.6	13.5	358	4.83	8.94	6.4	7.78	4.9	6.82	3.5
26	63.4	47.5	15.9	429	6.82	11.48	5.3	10.06	4.0	8.94	2.7
28	63.6	46.0	17.6	508	8.94	13.90	4.5	12.56	3.5	11.48	2.5
30	64.1	44.7	19.4	592	11.48	16.68	3.8	15.28	2.9	13.90	1.9
					3-LOG-TREES, GRADE 1-1-3						
26	87.1	46.3	40.8	594	24.24	38.30	4.7	34.51	3.6	30.91	2.5
28	89.0	44.9	44.1	701	30.91	46.82	4.2	42.49	3.2	38.30	2.2
30	91.0	44.0	47.0	815	38.30	56.06	3.9	51.63	3.0	46.82	2.0
32	93.1	43.4	49.7	942	46.82	66.30	3.5	61.27	2.7	56.06	1.8
34	95.2	43.1	52.1	1076	56.06	77.08	3.2	71.71	2.5	66.30	1.7
36	97.3	43.0	54.3	1221	66.30	88.10	2.8	82.59	2.2	77.08	1.5
					GRADE 1-2-3						
26	80.1	46.3	33.8	594	20.08	32.93	5.1	29.55	3.9	26.36	2.8
28	82.5	44.9	37.6	701	26.36	40.51	4.4	36.54	3.3	32.93	2.3
30	84.4	44.0	40.4	815	32.93	48.85	4.0	44.45	3.0	40.51	2.1
32	86.4	43.4	43.0	942	40.51	58.10	3.7	53.09	2.7	48.85	1.9
34	88.5	43.1	45.4	1076	48.85	67.45	3.3	62.53	2.5	58.10	1.7
36	90.7	43.0	47.7	1221	58.24	77.78	2.9	72.61	2.2	67.45	1.5

Table 4.—Rate of value increase of sweetgum, by log height, grade, diameter, and vigor class

Diam. breast high (inches)	Per M board feet: Gross lumber value	Direct costs	Conversion surplus	Lumber per tree	Conversion surplus per tree by vigor class: Now	High vigor: After 10 yrs.	High vigor: Annual increase	Medium vigor: After 10 yrs.	Medium vigor: Annual increase	Low vigor: After 10 yrs.	Low vigor: Annual increase
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	- - - Index - - - -			Bd.ft.	- Index - -		Percent	Index	Percent	Index	Percent
				1-LOG-TREES, GRADE 1							
18	89.3	61.6	27.7	122	3.38	6.58	6.9	5.59	5.2	4.64	3.2
20	90.7	57.4	33.3	154	5.13	8.80	5.5	7.63	4.0	6.58	2.5
22	92.1	54.4	37.7	190	7.16	11.40	4.8	10.04	3.4	8.80	2.1
24	93.6	52.0	41.6	226	9.40	14.35	4.3	12.84	3.2	11.40	1.9
26	95.1	50.1	45.0	269	12.10	17.55	3.8	15.95	2.8	14.35	1.7
28	96.7	48.7	48.0	312	14.98	21.12	3.5	19.29	2.6	17.55	1.6
30	98.4	47.6	50.8	363	18.44	25.15	3.2	23.00	2.2	21.12	1.4
32	100.2	46.9	53.3	416	22.17	29.47	2.9	27.15	2.1	25.15	1.3
34	102.1	46.5	55.6	469	26.08	34.10	2.7	31.80	2.0	29.47	1.2
36	104.3	46.5	57.8	530	30.63	38.52	2.3	36.30	1.7	34.10	1.1
				GRADE 2							
18	68.9	61.6	7.3	122	.89	3.28	13.9	2.50	10.9	1.83	7.5
20	71.2	57.4	13.8	154	2.13	4.91	8.7	4.04	6.6	3.28	4.4
22	73.6	54.4	19.2	190	3.65	6.94	6.6	5.89	4.9	4.91	3.0
24	76.0	52.0	24.0	226	5.42	9.38	5.6	8.11	4.1	6.94	2.5
26	78.5	50.1	28.4	269	7.64	12.24	4.8	10.80	3.5	9.38	2.1
28	80.9	48.7	32.2	312	10.05	15.43	4.4	13.79	3.2	12.24	2.0
30	83.6	47.6	36.0	363	13.07	18.84	3.7	17.07	2.7	15.43	1.7
32	86.0	46.9	39.1	416	16.27	22.67	3.4	20.69	2.4	18.84	1.5
34	88.6	46.5	42.1	469	19.74	26.98	3.2	24.83	2.3	22.67	1.4
36	91.2	46.5	44.7	530	23.69	31.40	2.8	29.14	2.1	26.98	1.3
				GRADE 3							
22	56.9	54.4	2.5	190	.47	2.33	17.3	1.72	13.8	1.18	9.6
24	58.4	52.0	6.4	226	1.45	3.70	9.8	3.00	7.5	2.33	4.9
26	60.0	50.1	9.9	269	2.66	5.40	7.3	4.52	5.4	3.70	3.4
28	61.8	48.7	13.1	312	4.09	7.34	6.0	6.32	4.4	5.40	2.8
30	63.7	47.6	16.1	363	5.84	9.44	4.9	8.38	3.7	7.34	2.3
				2-LOG-TREES, GRADE 1-2							
18	79.8	61.4	18.4	209	3.85	9.10	9.0	7.40	6.7	5.90	4.4
20	81.5	56.8	24.7	268	6.62	12.73	6.8	10.88	5.1	9.10	3.2
22	83.2	53.5	29.7	336	9.98	16.99	5.5	14.78	4.0	12.73	2.5
24	85.0	51.1	33.9	404	13.70	21.85	4.8	19.42	3.6	16.99	2.2
26	86.7	49.2	37.5	485	18.19	27.42	4.2	24.52	3.3	21.85	1.9
28	88.5	47.8	40.7	568	23.12	34.02	3.9	30.56	2.8	27.42	1.7
30	90.4	46.8	43.6	664	28.95	40.75	3.5	37.18	2.5	34.02	1.6
32	92.5	46.0	46.5	765	35.57	48.20	3.1	44.42	2.2	40.75	1.4
34	94.6	45.6	49.0	868	42.53	56.47	2.9	52.32	2.1	48.25	1.3
36	96.9	45.6	51.3	984	50.48	65.05	2.6	60.90	1.9	56.47	1.1
				GRADE 1-3							
18	74.1	61.4	12.7	209	2.65	7.15	10.4	5.73	8.0	4.42	5.2
20	75.7	56.8	18.9	268	5.07	10.33	7.4	8.70	5.5	7.15	3.5
22	77.1	53.5	23.6	336	7.93	13.83	5.7	12.00	4.2	10.33	2.7
24	78.7	51.1	27.6	404	11.15	18.14	5.0	15.92	3.6	13.80	2.2
26	79.8	49.2	30.6	485	14.84	23.08	4.5	20.52	3.3	18.14	2.0
28	81.8	47.8	34.0	568	19.31	28.75	4.1	25.84	3.0	23.08	1.8
30	83.6	46.8	36.8	664	24.44	34.40	3.5	31.63	2.6	28.75	1.6
32	85.5	46.0	39.5	765	30.22	40.20	2.9	37.10	2.1	34.40	1.3
				GRADE 2-3							
18	61.9	61.4	.5	209	.10	3.59	42.9	2.43	37.4	1.43	30.9
20	64.0	56.8	7.2	268	1.93	6.19	12.9	4.87	9.7	3.59	6.4
22	66.1	53.5	12.6	336	4.23	9.33	8.2	7.68	6.1	6.19	3.9
24	68.2	51.1	17.1	404	6.91	13.14	6.6	11.18	4.9	9.33	3.0
26	70.3	49.2	21.1	485	10.23	17.55	5.6	15.28	4.1	13.14	2.5
28	72.7	47.8	24.9	568	14.14	22.71	4.8	20.05	3.6	17.55	2.2
30	75.1	46.8	28.3	664	18.79	28.32	4.2	25.39	3.1	22.71	1.9
32	77.4	46.0	31.4	765	24.02	34.60	3.7	31.44	2.7	28.32	1.7

Table 4.--(Continued)

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Direct costs (3)	Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	High vigor: Annual increase (8)	Medium vigor: After 10 yrs. (9)	Medium vigor: Annual increase (10)	Low vigor: After 10 yrs. (11)	Low vigor: Annual increase (12)
	Index			Bd.ft.	Index		Percent	Index	Percent	Index	Percent
					GRADE 3-3						
20	57.2	56.8	.4	268	.11	3.89	42.6	2.72	37.6	1.61	30.8
22	59.8	53.5	6.3	336	2.12	6.53	11.6	5.16	9.3	3.89	6.3
24	62.2	51.1	11.1	404	4.48	9.38	7.7	7.96	5.9	6.53	3.8
26	64.1	49.2	14.9	485	7.23	12.27	5.4	10.52	4.1	9.38	2.6
28	65.6	47.8	17.8	568	10.11	15.29	4.2	13.72	3.1	12.27	2.0
30	66.5	46.8	19.7	664	13.08	18.42	3.5	16.84	2.6	15.29	1.6
32	67.0	46.0	21.0	765	16.06	21.85	3.1	20.10	2.3	18.42	1.4
					3-LOG-TREES, GRADE 1-1-2						
24	87.9	51.4	36.5	540	19.71	30.86	4.6	27.45	3.4	24.24	2.1
26	89.0	49.4	39.6	654	25.90	38.39	4.0	34.50	2.9	30.86	1.8
28	90.2	47.9	42.3	772	32.66	46.85	3.7	42.54	2.7	38.39	1.6
30	91.3	46.8	44.5	908	40.41	55.70	3.3	51.17	2.4	46.85	1.5
32	92.5	45.9	46.6	1054	49.12	65.43	2.9	60.50	2.1	55.70	1.3
34	93.8	45.4	48.4	1202	58.18	75.58	2.6	70.50	1.9	65.43	1.2
36	95.0	45.3	49.7	1369	68.04	85.75	2.3	80.73	1.7	75.58	1.0
					GRADE 1-1-3						
24	83.5	51.4	32.1	540	17.33	27.55	4.7	24.45	3.5	21.63	2.2
26	84.6	49.4	35.2	654	23.02	34.45	4.1	30.87	3.0	27.55	1.8
28	85.7	47.9	37.8	772	29.18	42.30	3.8	38.25	2.7	34.45	1.6
30	86.8	46.8	40.0	908	36.32	50.43	3.3	46.32	2.5	42.30	1.5
32	88.0	45.9	42.1	1054	44.37	59.24	2.9	54.70	2.1	50.43	1.3
34	89.1	45.4	43.7	1202	52.53	68.65	2.7	64.02	2.0	59.24	1.2
36	90.3	45.3	45.0	1369	61.60	77.75	2.4	73.31	1.8	68.65	1.1
					GRADE 1-2-2						
20	79.0	57.5	21.5	349	7.50	14.85	7.1	12.55	5.3	10.22	3.1
22	80.1	54.0	26.1	443	11.56	19.97	5.6	17.28	4.1	14.85	2.5
24	81.1	51.4	29.7	540	16.04	25.79	4.9	22.80	3.6	19.97	2.2
26	82.2	49.4	32.8	654	21.45	32.38	4.2	28.98	3.1	25.79	1.9
28	83.3	47.9	35.4	772	27.33	39.84	3.8	36.00	2.8	32.38	1.7
30	84.5	46.8	37.7	908	34.23	47.62	3.4	43.61	2.5	39.84	1.5
32	85.6	45.9	39.7	1054	41.84	56.11	3.0	51.86	2.2	47.62	1.3
34	86.8	45.4	41.4	1202	49.76	65.03	2.7	60.60	2.0	56.11	1.2
36	88.0	45.3	42.7	1369	58.46	73.75	2.4	69.38	1.7	65.03	1.1
					GRADE 1-2-3						
18	74.0	62.3	11.7	267	3.12	8.78	10.9	6.97	8.4	5.30	5.4
20	75.0	57.5	17.5	349	6.11	12.82	7.7	10.73	5.8	8.78	3.7
22	76.1	54.0	22.1	443	9.79	17.55	6.0	15.05	4.4	12.82	2.7
24	77.1	51.4	25.7	540	13.88	22.88	5.1	20.13	3.8	17.55	2.4
26	78.2	49.4	28.8	654	18.84	28.95	4.4	25.82	3.2	22.88	2.0
28	79.3	47.9	31.4	772	24.24	35.84	4.0	32.25	2.9	28.95	1.8
30	80.5	46.8	33.7	908	30.60	43.08	3.5	39.39	2.6	35.84	1.6
32	81.6	45.9	35.7	1054	37.62	51.10	3.1	46.95	2.2	43.08	1.4
34	82.8	45.4	37.4	1202	44.95	59.85	2.9	55.42	2.1	51.10	1.3
36	84.2	45.3	38.9	1369	53.25	68.92	2.6	64.35	1.9	59.85	1.2
					GRADE 1-3-3						
18	69.9	62.3	7.6	267	2.03	7.10	13.3	5.45	10.4	3.95	6.9
20	71.0	57.5	13.5	349	4.71	10.75	8.6	8.85	6.5	7.10	4.2
22	72.1	54.0	18.1	443	8.02	15.00	6.5	12.45	4.5	10.75	3.0
24	73.2	51.4	21.8	540	11.77	19.83	5.4	17.32	3.9	15.00	2.4
26	74.2	49.4	24.8	654	16.22	25.38	4.6	22.50	3.3	19.83	2.0
28	75.3	47.9	27.4	772	21.15	31.64	4.1	28.47	3.0	25.38	1.8
30	76.4	46.8	29.6	908	26.88	38.30	3.6	34.95	2.7	31.64	1.6
32	77.6	45.9	31.7	1054	33.41	45.67	3.2	41.96	2.3	38.30	1.4
34	78.8	45.4	33.4	1202	40.15	53.60	2.9	49.58	2.1	45.67	1.3
36	80.1	45.3	34.8	1369	47.64	61.83	2.6	57.68	1.9	53.60	1.2

Butt logs of small trees are subject to radical improvement in grade once the limbs are dropped, because of the increasing thickness of clear wood deposited over the heart center. The same thing happens, though to a lesser degree, to upper logs. Furthermore, logs may improve in grade merely with increase in diameter. In the upper bole, additional logs are created as girth is added to meet minimum specifications and as the bole is cleared so as to meet quality specifications. Thus small, short hardwoods of low grade are often capable of developing into 2- or 3-log, high-grade trees. Generally, most of the potential improvement in grade is realized by the time a hardwood tree reaches 24 or 26 inches d. b. h., though exceptions may be found in the improvement in quality of low-grade upper logs. Most large hardwoods are likely to have their log height firmly established by the position and form of the crown.

Potential changes in log height and grade can, with experience, be recognized by the forester or woodsman. To recognize them is essential in determining financial maturity.

Tables 3 and 4 may be used as a basis for calculating (though not for reading directly) the rate of value increase for trees expected to grow in log height or improve in grade. Suppose that the two-log, 28-inch, grade 1-2 Nuttall oak is expected to add a third log in the coming decade, so as to become a 32-inch, grade 1-2-3 tree. Table 3 shows that the value now is index 22.96, and that the value in 10 years (reading in the same column, opposite the expected grade and diameter) will be index 40.51. A calculation of the ratio of these indexes and reference to compound-interest tables discloses that the expected rate of increase is 5.8 percent. With a 5-percent alternative rate, this tree is not yet mature.

In the same way, it is possible to evaluate prospective increases in grade, or in both height and grade. If the grade 1-2 Nuttall oak grows to grade 1-1-3 in 10 years, the rate of value increase will be even higher, 7.4 percent.

As managed trees grow from 18 to 36 inches in d. b. h., they may be expected to improve in quality and log height about in the stages shown in column 2 of table 5. That is, a high-vigor 18-inch tree with one grade 2 log will grow into a 22-inch grade 2-3 tree in 10 years. In doing so it will earn 17.1 percent annually (col. 3), substantially more than the 13.2 percent (col. 4) it would have made without these changes. A comparison of columns 3 and 4 of table 5 will demonstrate the marked effect that changes in log grade and height have upon a tree's earning power. It is clear that any tree that is placed by table 3 or 4 near the borderline of financial maturity should be left for additional growth if it promises to extend its log height or improve its grade.

Step 6 --Effect of Other Trees

In judging financial maturity, one cannot, of course, consider a tree solely on its own merits. Every forest tree is in more or less competition with other trees, and this competition affects the desirability of the tree as an investment. Some trees which, judged alone, are apparently financially mature turn out not to be mature when one or more other trees are brought into consideration. Likewise, trees may prove to be mature which, considered by themselves, were not so. The principle covering the effect of other trees upon financial maturity is this: the aim of the manager should be to maintain on each acre that volume of timber which, within the requirements of the silvicultural system and the program of regulation, has the greatest possible conversion surplus in trees not yet financially mature. For reasons made clear in the reference cited in footnote 2, this principle will result in securing the highest income from each acre that the alternative rate of return will afford.

Therefore, where two competing trees are both mature, but where removal of one would raise the vigor of the other sufficiently to make it no longer mature, a general rule is to retain that tree for growth which has the higher value, now or prospectively--the greater size or higher grade, or the better

Table 5. --Rate of value increase for managed trees of high vigor, with and without log height and grade changes

Tree d. b. h. (inches)	Tree grade	Annual conversion-surplus increase	
		With height and grade changes	Without height and grade changes
(1)	(2)	(3)	(4)
		Percent	
		RED OAKS	
18	2	17.1	13.2
20	2-3	13.6	9.7
22	2-3	13.0	7.4
24	1-3	7.6	5.9
26	1-2	6.3	5.0
28	1-2	5.8	4.4
30	1-2-3	5.5	4.0
32	1-2-3	5.0	3.7
34	1-1-3	...	3.2
36	1-1-3	...	2.8
		SWEETGUM	
18	2-3	53.0	42.9
20	1-3	9.7	7.4
22	1-3-3	8.1	6.5
24	1-2-3	6.4	5.1
26	1-2-3	5.6	4.4
28	1-2-2	5.5	3.8
30	1-2-2	5.0	3.4
32	1-1-2	...	2.9
34	1-1-2	...	2.6

chance of increasing its size or improving its grade. The other tree should be cut.

Take the case of two competing red oaks. Both are of medium vigor, but if either is cut, the vigor of the other will become high. Following are the pertinent data on these oaks, read from table 3:

	Tree A	Tree B
D.b.h., inches	26	28
Two-log trees, grade	1-2	2-3
Conversion surplus	17.80	14.02
Medium vigor:		
Conversion surplus after 10 years	25.85	20.07
Rate of increase, percent	3.8	3.7
High vigor:		
Conversion surplus after 10 years	28.89	22.47
Rate of increase, percent	5.0	4.8

With a 4-percent alternative rate of return, one of the trees is mature and should be cut, while the other should be left to grow one more cycle. Since Tree A, the 26-inch grade 1-2 oak, has the higher value both now and prospectively, it should be left to grow.

A comparison of these alternative trees will show the reasoning behind the rule. For convenience, assume that conversion surplus equals dollars. Then if B is cut, its $14.02 will earn $6.73 in ten years at 4 percent compound interest. Tree A will earn $11.09 ($28.89-17.80). The total earnings of both trees will thus be $17.82. Suppose A is cut; its $17.80 will earn $8.54 at 4 percent while tree B earns $8.45 ($22.47 -14.02); the total earnings of both trees will be $16.99. This earning is 83 cents less than is derived from the alternative of cutting B; therefore, tree A should be left to grow, and tree B marked for cutting. The rule is designed to cover the vast majority of the numerous alternatives facing the forest manager. There will be exceptions, but the virtue of the rule is that it obviates making separate calculations for every alternative that arises.

Other considerations relating to the stand may affect the financial-maturity decision. A tree may be otherwise mature and still not ready for harvest if it is needed as a seed source. Again, the need for holding the cut within a cutting budget, or of building the growing stock towards optimum diameter-class distributions, may result in leaving for another cutting cycle some trees that apparently are financially mature. In some areas there may be insufficient timber volume to support a com-

mercial cutting operation despite a sprinkling of "mature" trees. On the other hand, the owner may be forced to cut some trees in order to obtain a regular income or a regular supply of logs for a sawmill; these are cases where the alternative rate of return has risen, at least temporarily.

A related problem is the case of trees smaller than sawlog size. For such timber, financial-maturity decisions are rather easily reached. Trees between 8 and 14 inches in diameter usually have boles sufficiently well defined so that development in sawlog length and quality can be predicted with fair accuracy. All low-grade trees interfering with the growth of better stems should be eliminated--and utilized if possible. In general, low-grade trees, especially those that promise to develop no better than a grade-3 butt log, should not be permitted to grow in competition with better trees. Comparing the prospective earnings of such trees with the earnings that may be obtained from higher grade trees will generally show that the low-grade trees reach financial maturity while still below sawlog size. For the poorest specimens, outright deadening may often be justified.

Two other points have yet to be considered. The first of these is that the percentage rates of increase and index values are not directly comparable for competing trees of different species groups. Each group has its own index base, and only if No. 1 Common and Selects red oak sold consistently for the same price as that of sweetgum would the two species be comparable. Although differences in the base value do exist, they are not great. Sometimes oak sells at the higher price and at other times sweetgum does. On the average for the base period, sweetgum was somewhat more valuable than red oak, but by less than 10 percent. Consequently, no great harm will result if direct comparisons are made, provided that where the decision is close a sweetgum is favored over a red oak.

The other point relates to the super-vigorous red oaks capable of growing an average of 6 inches in 10 years. For such trees table 6 (on the following page) should be used in judging financial maturity, since table 3 seriously underestimates their rate of value increase. Table 3 shows that an ordinary high-vigor 3-log 28-inch red oak, grade 1-2-3, is capable of earning 4.4 percent, compound, over the next ten years. If the same tree were of super-vigor, its rate would be 6.3 percent (table 6). Super-vigorous red oaks are by no means exceptional on good sites, and their strikingly superior earning powers merit the forester's special attention. He should assiduously seek out such trees as they approach lumber-log size and then guard them, cutting cycle by cutting cycle, against premature harvesting.

Table 6.--Rate of value increase of super-vigorous red oaks by log height, grade, and diameter

Diam. breast high (inches)	Conversion surplus per tree		Annual increase	Conversion surplus per tree		Annual increase
	Now	After 10 years		Now	After 10 years	
	- - - - Index - - - -		Percent	- - - - Index - - - -		Percent
	GRADE 1-2			GRADE 1-3		
18	3.55	13.35	14.2	2.38	11.03	16.6
20	6.32	17.80	10.9	4.84	14.97	11.9
22	9.56	22.96	9.1	7.70	19.61	9.8
24	13.35	28.89	8.0	11.03	24.75	8.4
26	17.80	35.24	7.1	14.97	31.01	7.6
28	22.96	42.28	6.3	19.61	36.00	6.3
30	28.89	49.95	5.6	24.75	41.90	5.4
32	35.24	57.79	5.1	31.01	47.70	4.4
34	42.28	65.87	4.5			
36	49.95	73.95	4.0			
	GRADE 1-1-3			GRADE 1-2-3		
26	24.24	46.82	6.8	20.08	40.51	7.2
28	30.91	56.06	6.1	26.36	48.85	6.3
30	38.30	66.30	5.6	32.93	58.10	5.8
32	46.82	77.08	5.1	40.51	67.45	5.2
34	56.06	88.10	4.6	48.85	77.78	4.8
36	66.30	99.10	4.1	58.24	87.88	4.2

Simplified Marking Guides

Before the data and methods developed in this paper can readily be put to use in the woods, simplified marking guides based on them must be set up.

For best results, each manager would work out guides to fit his own conditions. To do so, however, is not a simple matter and requires the services of an experienced technical forester. Table 7 has been developed for average conditions. Here are listed for each vigor class and three common alternative rates of return the largest sizes of trees that should be left to grow one more 10-year period. The diameter spread allows for differences in log height and grade; the user of the tables must exercise judgment in favoring the more promising trees.

In general, low-vigor sweetgum are financially mature regardless of diameter. All sweetgums 22 inches d. b. h. and larger that show no promise of developing better than a grade-3 butt log should be harvested, as should all red oaks of similarly low quality 24 inches or larger.

Table 7.--Simplified marking guides for a 10-year cutting cycle

Vigor class	Alternative rate of return		
	3 percent	4 percent	5 percent
	D. b. h., inches		
RED OAKS			
High	32-35	28-30	25-27
Medium	29-30	26-27	22-24
Low	24-25	21-22	19-21
SWEETGUM			
High	31-33	26-29	23-27
Medium	26-28	22-25	20-22

In applying the simplified guides, the principles relating to other trees, discussed in the foregoing section, should be recognized. Trees of less than high vigor, when they are to be released by cutting sufficiently to improve growth, should be promoted one vigor class before financial maturity is judged. Those trees which show promise of improvement in vigor class, grade, or stem length should be permitted to grow at least another cutting cycle. Where one of two competing trees is to be cut, it is best to take the one of lesser size, grade, or vigor; or the one with poorer prospects for improvement.

These guides are by no means the final answer for each forest manager. They can, however, be adapted and further simplified for any